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Document No. 12-05

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Report No. 12-05, supported by the US Navy Bureau of Medicine and Surgery, Washington, DC, under Work Unit No **60332**. The views expressed in this article are those of the authors and do not reflect the official policy or position of the Navy, Department of Defense, or the U.S. Government. Approved for public release; distribution is unlimited. This research was conducted in compliance with all applicable federal regulations governing the protection of human subjects (Protocol NHRC.2003.0025).

Abstract

Background: The health and physical fitness of US military forces are critical components of operational readiness. Service members who fail physical readiness and body composition standards may be at risk of discharge from the military. The aim of this study was to examine changes in physical readiness and body mass index (BMI) in US Navy service members with a deployment-related injury.

Methods: Pre- and post-injury physical readiness scores, BMI measurements, and vocational outcomes were obtained from military databases and analyzed for 293 male Navy personnel who were injured during deployment between January 2005 and September 2009.

Results: All aspects of postinjury Physical Readiness Test (PRT) performances declined from preinjury levels. Moderate to severe injury severity was a significant predictor of subsequent decline in overall PRT performance ($F = 19.9$, $df = 1$, $p < .001$). In addition, mean postinjury BMI (M = 27.4, SD = 3.4) was significantly higher than mean preinjury BMI ($F = 79.0$, $df = 1$, $p < .001$; M = 26.1, SD = 2.9). A decline in overall PRT performance was significantly associated with military discharge ($\chi^2 = 4.6$, $df = 1$, $p = .032$). Changes in BMI, however, were not associated with vocational outcomes.

Conclusions: Overall, severity of deployment-related injury was associated with poor physical fitness after injury. Future research is needed to identify risk factors associated with these changes in injured combat veterans and should include a deployed, noninjured control group. Targeted education and prevention programs may be needed.

Background

The health and physical fitness of US military forces are critical components of operational readiness [1]. To function in a combat deployment environment where strength and endurance could determine operational success or failure, military personnel are required to maintain appropriate health and fitness levels. The US military currently employs physical readiness and body composition standards to facilitate and maintain a healthy, fit, and deployable force [2]. Service members who fail to meet these standards may not be deployable and may also be at risk of discharge from the military [3].

To date, more than 1.6 million US military personnel have been deployed in support of the wars in Iraq and Afghanistan [4]. These conflicts have yielded the most deployment-related casualties since the Vietnam War [5, 6]. Because of significant advances in battlefield medicine and protective equipment, service members are more often surviving their wounds [7–9]. In addition to suffering from an array of negative psychological and cognitive outcomes following the circumstances of these injuries [10, 11], many wounded service members may be limited, or even prohibited, from participating in physical fitness and training activities [9]. Physical inactivity has been linked to an increase in body mass index (BMI) and poor health outcomes [12, 13].

Although physical readiness and body composition measures have been widely investigated in military samples, including deployed military personnel, [14–17], they have not been studied among wounded service members. The primary aim of this study was to examine changes in physical readiness and BMI in US Navy service members with a deployment-related injury from Operation Iraqi Freedom (OIF), and to assess the impact of these changes on vocational outcomes.

Methods

Study sample

A retrospective cohort study was performed to investigate changes in physical readiness and BMI among male, Navy personnel who sustained injuries during deployment in support of OIF. The study period was between January 2005 and September 2009. The sample was identified from the Expeditionary Medical Encounter Database (EMED), formerly known as the Navy-Marine Corps Combat Trauma Registry. The EMED is a deployment health database maintained by the Naval Health Research Center, in San Diego, California. The database contains documented clinical encounters of deployed military personnel. Records are obtained for battle injury, nonbattle injury, disease, psychiatric, and routine sick-call encounters [18].

Only patients with single-injury events (battle or nonbattle) in the EMED and Physical Fitness Assessments within 2 years of injury were included in the present study. Physical Fitness Assessments were obtained from the Physical Readiness Information Management System (PRIMS), a database that contains semi-annual results of Navy service members' Physical Readiness Test (PRT) and Body Composition Assessment [2].

Measures

Demographic and injury-specific variables. Demographic information included age, military rank, and type of injury extracted from the clinical records in EMED. Age was categorized as 19–22, 23–28, and ≥29 years. Rank was categorized as junior enlisted (E1–E4), mid-level enlisted (E5–E7), and senior enlisted/officer (E8 and higher). Type of injury was categorized as battle, defined as those who suffered injury during hostile action, or nonbattle, defined as those who sustained injury from nonhostile causes. The Injury Severity Score (ISS) was used to characterize the overall injury severity of each patient. The ISS

ranges from 0 to 75, and because the population sustained primarily mild injuries, ISS was categorized into mild (1–3) and moderate to severe (≥4) [19].

Physical Readiness Test. The PRT is a component of the Physical Fitness Assessment [2]. In the present study, PRT scores for the following measures were obtained from PRIMS and used to assess levels of physical readiness in each patient: core strength, muscular strength, cardiovascular endurance, and overall performance. Core and muscular strength were evaluated by the number of sit-ups and push-ups each person performed in a 2-minute period. Cardiovascular endurance was assessed through time to complete a 1.5-mile run/walk, 500-yard swim, or 12-minute elliptical trainer test. The overall PRT scores are compared with Navy standards, set from a sample of 200,000 service members, and classified by performance levels: outstanding (90–100), excellent (75–89), good (60–74), satisfactory (50–59), and unsatisfactory (0–50) [2]. Service members may not be required to participate in the PRT for any one of the following reasons: deployment, medical waiver, temporary assigned duty, unexcused absence, or attendance of less than 10 weeks at current command [2].

Body Composition Assessment. Service members' height and weight are reported in PRIMS and were used in the present study to calculate BMI as a proxy measure for the Body Composition Assessment component of the Physical Fitness Assessment [20]. BMI was calculated as [(weight in pounds/height in inches^2) * 703] and was categorized into: underweight (<18.5), healthy (18.5–24.9), overweight (25.0–29.9), and obese (≥30.0) [21].

Vocational Outcomes. The vocational or career outcomes of interest included discharge, promotion, and re-deployment. Discharges were identified through personnel events from the Career History Archival Medical and Personnel System (CHAMPS), which includes demographic, career, and medical information for all active duty personnel in the US Armed Forces since 1973 [22]. Promotions were identified through CHAMPS and were

determined by an increase in military rank. Re-deployment was assessed by service members having a deployment following their assessments. Each of these outcome events were examined for 365 days following the PRT and Body Composition Assessment.

Statistical analysis

We used a paired-sample *t* test to assess the overall difference between pre- and post-injury PRT and BMI, and a repeated-measures analysis of variance test to assess pre- and post-injury PRT scores and BMI measurements by demographic and injury-specific variables. We used χ^2 tests to assess the association of change overall PRT performance and BMI by vocational outcomes. All tests were two-tailed and $p < 0.05$ was used to determine statistical significance. Statistical analyses were performed using SPSS software, version 17.0 (SPSS, Inc., Chicago, IL).

Results

Two hundred ninety-three male, Navy service members were included in the analyses. The median age at injury was 26 years and ranged from 19 to 57. Of the 293 service members, the majority were junior enlisted (54.3%), sustained injury from nonbattle causes (63.1%), and suffered minor injuries (ISS 1–3, 77.1%) (Table 1).

Physical Readiness Test

Figure 1 illustrates the pre- and post-injury distribution of service members with good to outstanding scores by type of PRT assessment. The overall PRT scores significantly declined following deployment-related injury (M = 75.3, SD = 14.1 vs. M = 73.7, SD = 15.5; $F = 4.1$, $df = 1$, $p = .045$). But when each component was assessed independently, only cardiovascular endurance was significantly reduced postinjury, $t(165) = 2.2$, $p = .028$. Changes in overall PRT scores by injury-specific and demographic characteristics are shown for pre- and post-injury performances in Table 2. Overall, postinjury PRT scores did not differ by age, rank,

type of injury, or BMI. Injury severity, however, was a significant predictor for subsequent overall PRT performance ($F = 19.9$, $df = 1$, $p < .001$). For those sustaining moderate to severe injuries, overall postinjury PRT performance declined by 11.9% from preinjury PRT performance (Table 2).

Body Composition Assessment

Figure 2 demonstrates that postinjury BMI (M = 27.4, SD = 3.4) was significantly higher than preinjury BMI (M = 26.1, SD = 2.9; $F = 79.0$, $df = 1$, $p < .001$). Changes in BMI from pre- to post-injury measurement by injury-specific and demographic characteristics are shown in Table 3. On average, BMI increased by 5.0% from pre- to post-injury measurement. Change in BMI was statistically associated with age and rank. Service members aged 19–22 years had the greatest percent increase in BMI from pre- to post-injury compared with those aged 23–28 or 29 years and older (6.7% vs. 4.5% and 3.4%, respectively; $F = 3.3$, $df = 2$, $p = .038$). Similarly, junior enlisted personnel had a larger percent increase in BMI than mid-level enlisted personnel or senior enlisted/officers (6.2% vs. 3.0% and 4.6%, respectively; $F = 3.1$, $df = 2$, $p = .047$). Type of injury, injury severity, and PRT performance were not associated with changes in BMI.

Vocational Outcomes

Vocational outcomes were assessed for 1 year after the PRT and Body Composition Assessment (Table 4). A statistically higher proportion of service members with a decline in overall PRT performance were discharged compared with those who did not have a decline in PRT performance ($\chi^2 = 4.6$, $df = 1$, $p = .032$). Change in overall PRT performance, however, was not associated with promotion or re-deployment. In addition, no statistical differences were found in vocational outcomes by changes in BMI.

Discussion

To our knowledge, this study is the first to examine the effect of a deployment-related injury on physical readiness and body composition measures. A primary finding was the association between injury severity and overall PRT performance, where those with moderate to severe injury had a 12% decline in PRT score compared with less than 1% decline among those with mild injuries. This finding is not altogether surprising, as moderate to severe injuries are known to be associated with poor physical outcomes in various military populations [11, 23]. But it is somewhat encouraging that mild injury, which accounted for 77% of all injuries, does not appear to have much of an effect, if any, on physical readiness as measured by the PRT. This may reflect successful treatment and rehabilitation of mild injuries, both in combat theatre and upon return from deployment. Providers involved in rehabilitation of injured military personnel may want to target military physical readiness standards as a treatment goal for their patients, particularly since this analysis also found that a decline in the PRT score was associated with military discharge.

There was a modest, overall increase in BMI from pre- to post-injury levels. This finding contrasts a study by Jacobsen, et al. that found no change in weight among male, deployed military personnel [15]. The Jacobsen study, however, did not assess physical injury during deployment and used self-report weight measures, which may have biased the results. Physical injury may in fact play a role in BMI increase, though the clinical relevance of this small, yet statistically significant, increase warrants further investigation.

Interestingly, changes in BMI were neither associated with injury severity nor PRT performance. The use of BMI as a measure of general health and fitness in young military populations may be problematic because it does not differentiate between muscle mass and adipose tissue, which may overestimate adiposity in service members with large muscle mass. The BMI's utility as a fitness indicator among military personnel requires further research. Alternatively, PRT performance may be a valuable measure of functional outcome

among military personnel. Typically, functional outcome following injury has been measured in civilian populations with return to work rates and life satisfaction scores [24, 25]. Because of the emphasis on physical readiness in the military, as well as its potential impact on retention [3], further use of this measure in military outcomes research may be useful.

The primary strength of the present study was the use of pre- and post-injury measures for physical fitness—particularly the BMI measure, which was not limited by self-report. The use of these measures allowed for a temporal assessment of physical readiness scores, BMI, and vocational outcomes. In addition, the use of the EMED to identify physical injuries allowed for accurate assessment of injury severity directly from provider notes in clinical records. The main limitation of this analysis is the use of the PRIMS database for physical fitness measures, as it has not been previously validated for research purposes. We were also unable to ascertain and control for risk factors associated with poor physical health such as smoking, diet, and alcohol consumption [17, 26].

Conclusions

Our findings suggest that negative effects on physical fitness may be another unfortunate consequence of deployment-related injury in military personnel. Future studies on the association between deployment-related injury and physical fitness outcomes would benefit from a larger sample size, as well as the inclusion of a deployed, noninjured comparison group. Physical fitness is a key aspect of military service and can affect career progression. Development of targeted rehabilitation efforts for those with more severe injuries focusing on a return to preinjury physical standards may be warranted.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

KH made substantial contributions to study conception, design, data analyses, interpretation, and writing of the manuscript. AD made substantial contributions to study design, data analyses and interpretation, writing and critically revising the manuscript for important intellectual content. AM made substantial contributions to study conception and design, acquisition of PRT data, writing of the manuscript, and final approval of the version to be published. MG made substantial contributions in acquisition of deployment-related injury data and final approval of the version to be published. All authors read and approved the final manuscript.

Acknowledgments

The authors thank Science Applications International Corporation, Inc., for its contributions to this work. We would also like to thank Physical Readiness Information Management System for providing physical readiness and body composition data.

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FIGURE LEGENDS

Figure 1. Percentage of Navy service members by pre- and post-injury Physical Readiness Test (PRT) scores. Pre- and post-injury overall PRT scores were significantly different, $F = 4.1$, $df = 1$, $p = .045$.

Pre- and post-injury core strength PRT scores were not significantly different, $t(172) = 0.4$, $p = .705$.

Pre- and post-injury muscular strength PRT scores were not significantly different, $t(167) = 0.9$, $p = .354$.

Pre- and post-injury cardiovascular endurance PRT scores were significantly different, $t(165) = 2.2$, $p = .028$.

Figure 2. Comparison of mean body mass index (BMI) from pre- to post-injury among Navy service members (N = 293). Postinjury BMI was statistically higher than preinjury BMI, $F = 79.0$, $df = 1$, $p < .001$.

Table 1: Descriptive postinjury characteristics of US Navy service members, 2005–2009 (N = 293)

Characteristics	N	(%)
Median age (range), years	26	(19–57)
Type of injury		
Nonbattle	185	(63.1)
Battle	108	(36.9)
Rank		
Junior enlisted	159	(54.3)
Mid-level enlisted	85	(29.0)
Senior enlisted/officers	33	(11.3)
Not documented	16	(5.5)
Injury severity		
Mild (1–3)	226	(77.1)
Moderate to severe (≥4)	67	(22.9)
Postinjury PRT performance		
Good to outstanding	184	(77.0)
Satisfactory or fail	28	(11.7)
Waived[a]	27	(11.3)
Postinjury BMI		
18.5–24.9	61	(20.8)
25.0–29.9	171	(58.4)
≥30	61	(20.8)

BMI, body mass index; PRT, Physical Readiness Test.

[a]Subjects were waived for medical reasons, temporary assigned duty, deployment, preventive health assessment not completed, or <10 weeks at current command.

Table 2: Changes in mean overall postinjury Physical Readiness Test performance among Navy service members, 2005–2009

Characteristics	Overall Physical Readiness Test performance (PRT)[a,b] (Mean ± SD)			*p* value	F	(*df*)
	Preinjury	Postinjury	Change in PRT (%)			
Overall	75.3 ± 14.1	73.7 ± 15.5	-1.6 (2.1)	.045	4.07	(1)
Age, years				.637	0.45	(2)
19–22	71.0 ± 11.2	68.6 ± 14.1	-2.4 (3.4)			
23–28	75.9 ± 15.2	75.4 ± 16.1	-0.5 (0.7)			
≥29	77.3 ± 14.6	75.4 ± 15.6	-1.9 (2.5)			
Rank				.923	0.08	(2)
Junior enlisted	72.8 ± 12.5	71.7 ± 13.4	-1.1 (1.5)			
Mid-level enlisted	75.2 ± 16.2	73.4 ± 18.7	-1.8 (2.4)			
Senior enlisted/officers	85.0 ± 12.8	83.9 ± 13.3	-1.1 (1.3)			
Type of injury				.921	0.01	(1)
Nonbattle	75.0 ± 13.9	73.4 ± 16.0	-1.6 (2.1)			
Battle	75.8 ± 14.6	74.1 ± 14.7	-1.7 (2.2)			
Injury severity				<.001	19.94	(1)
Mild (1–3)	74.4 ± 13.8	74.6 ± 15.2	0.2 (0.3)			
Moderate to severe (≥4)	79.1 ± 15.1	69.7 ± 16.4	-9.4 (11.9)			
Preinjury body mass index				.083	2.52	(2)
18.5–24.9	76.6 ± 13.1	72.8 ± 15.6	-3.8 (5.0)			
25.0–29.9	76.3 ± 15.0	75.3 ± 15.9	-1.0 (1.3)			
≥30.0	65.0 ± 6.1	67.1 ± 10.9	2.1 (3.2)			
Postinjury body mass index[c]				.250	1.40	(2)
18.5–24.9	75.3 ± 10.8	71.7 ± 13.8	-3.6 (4.8)			
25.0–29.9	76.9 ± 15.2	75.7 ± 16.2	-1.2 (1.6)			
≥30.0	69.7 ± 12.6	70.2 ± 13.3	0.5 (0.7)			

[a]N = 174 service members completed a pre- and post-injury PRT. Subjects excluded from analyses were waived for medical reasons, temporary assigned duty, deployment, preventive health assessment not completed, or <10 weeks at current command.

[b]PRT categories: outstanding (90–100), excellent (75–89), good (60–74), satisfactory (50–59), do not meet Navy PRT standard (0–50).

[c]Underweight patients removed from analysis due to small sample (N = 2).

Table 3: Changes in mean body mass index among Navy service members, 2005–2009, (N = 293)

Characteristics	Body mass index (BMI)[a] (Mean ± SD)			*p* value	*F*	(*df*)
	Preinjury	Postinjury	Change in BMI (%)			
Overall	26.1 ± 2.9	27.4 ± 3.4	1.3 (5.0)[b]	<.001	78.98	(1)
Age, years				.038	3.32	(2)
19–22	25.2 ± 2.8	26.9 ± 4.0	1.7 (6.7)[b]			
23–28	26.4 ± 2.9	27.6 ± 3.2	1.2 (4.5)			
≥29	26.6 ± 2.8	27.5 ± 3.1	0.9 (3.4)			
Rank				.047	3.08	(2)
Junior enlisted	25.9 ± 2.8	27.5 ± 3.7	1.6 (6.2)[b]			
Mid-level enlisted	26.7 ± 2.9	27.5 ± 3.1	0.8 (3.0)			
Senior enlisted/officers	26.0 ± 2.3	27.2 ± 2.6	1.2 (4.6)			
Type of injury				.992	0.00	(1)
Nonbattle	26.1 ± 2.9	27.3 ± 3.4	1.2 (4.6)			
Battle	26.3 ± 2.9	27.5 ± 3.4	1.2 (4.6)			
Injury severity				.341	0.91	(1)
Mild (1–3)	26.1 ± 2.9	27.3 ± 3.4	1.2 (4.6)			
Moderate to severe (≥4)	26.2 ± 3.0	27.6 ± 3.5	1.4 (5.3)[b]			
Preinjury overall PRT[c]				.580	0.55	(2)
Good to outstanding	26.1 ± 2.9	27.2 ± 3.4	1.1 (4.2)			
Satisfactory or fail	27.5 ± 3.8	29.2 ± 4.1	1.7 (6.2)[b]			
Waived	24.4 ± 2.3	25.3 ± 3.1	0.9 (3.7)			
Postinjury overall PRT[c]				.169	1.79	(2)
Good to outstanding	26.0 ± 2.8	27.4 ± 3.2	1.4 (5.4)[b]			
Satisfactory or fail	25.5 ± 3.1	27.5 ± 3.6	2.0 (7.8)[b]			
Waived	26.5 ± 2.6	27.4 ± 3.6	0.9 (3.4)			

PRT, Physical Readiness Test.

[a]BMI categories: underweight (<18.5), healthy (18.5–24.9), overweight (25.0–29.9), and obese (≥30.0).

[b]Clinically significant increase in BMI.[27]

[c]Subjects were waived for temporary assigned duty, deployment, preventive health assessment not completed, or <10 weeks at current command.

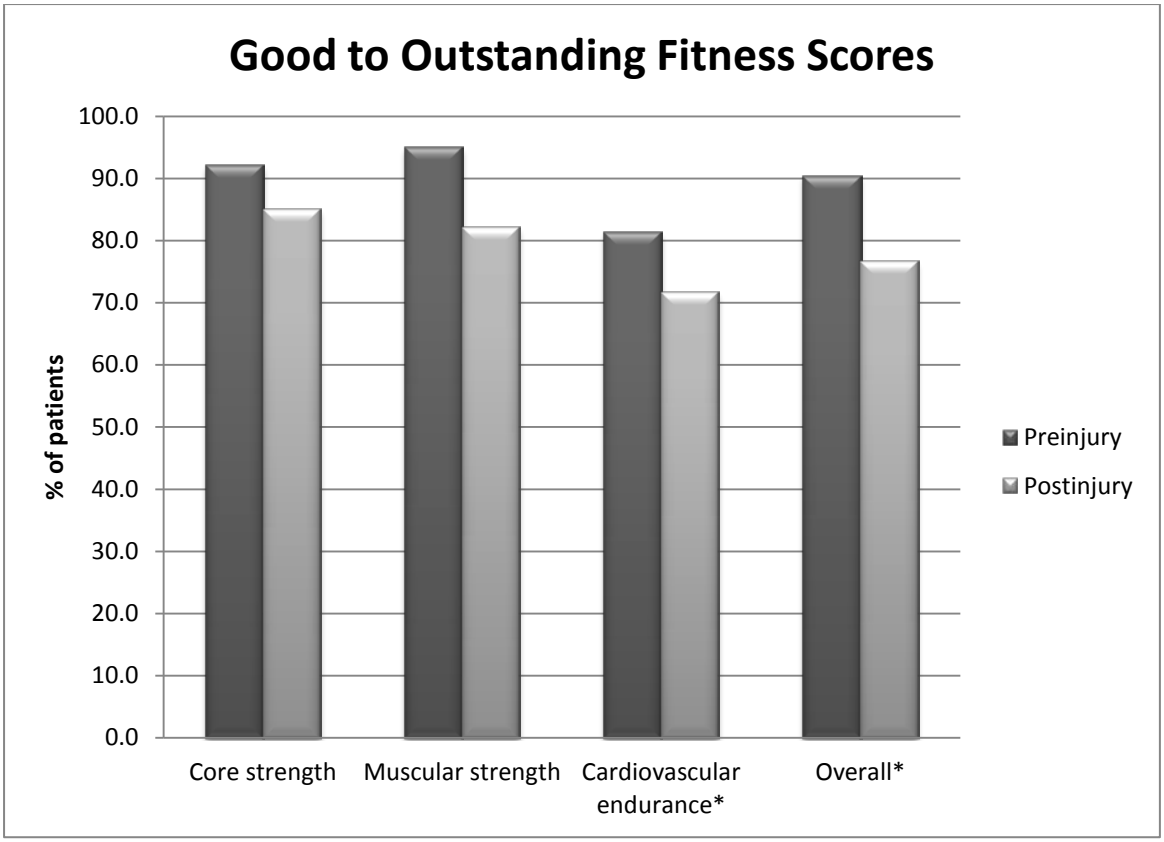
Table 4: Assessment of vocational outcomes by changes in body mass index and Physical Readiness Test performance among Navy service members, 2005–2009, (N = 293)

Vocational outcomes	Change in overall PRT					Change in BMI				
	Decline (*n* = 77)		No Decline (*n* = 97)		*p* value	> = 5% increase (*n* = 140)		< 5% increase (*n* = 153)		*p* value
	N	(%)	*N*	(%)		*N*	(%)	*N*	(%)	
Redeployment	19	(24.7)	29	(29.9)	.444	30	(21.4)	32	(20.9)	.914
Discharge	16	(20.8)	9	(9.3)	.032	19	(13.6)	31	(20.3)	.128
Promotion[†]	13	(16.9)	8	(8.2)	.082	18	(12.9)	27	(17.6)	.257

PRT, Physical Readiness Test; BMI, body mass index.

Note. Re-deployment, discharge and promotion events within 365 days of BMI and PRT assessment were included.

[†] Promotion is indicated by an increase in military rank.


Good to Outstanding Fitness Scores
% of patients
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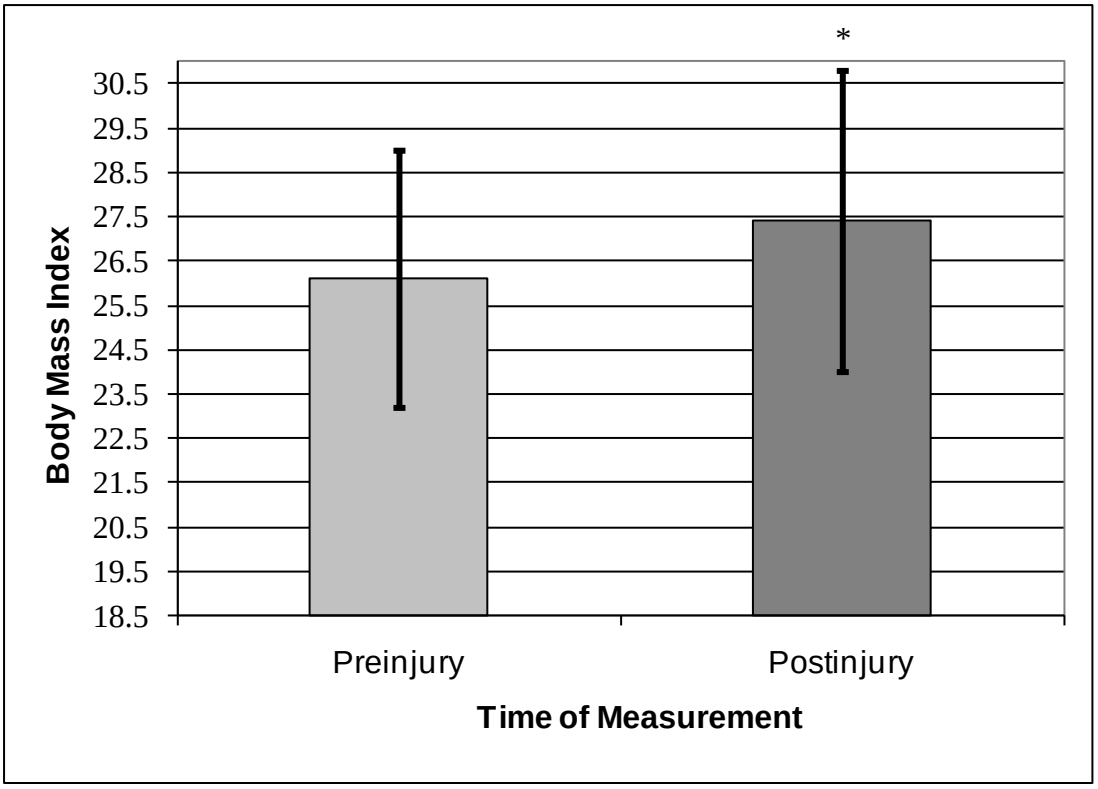
Core strength
Muscular strength
Cardiovascular endurance*
Overall*
Preinjury
Postinjury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30.5
29.5
28.5
27.5
26.5
25.5
24.5
23.5
22.5
21.5
20.5
19.5
18.5
Body Mass Index
Preinjury
Postinjury
Time of Measurement

REPORT DOCUMENTATION PAGE

1. REPORT DATE (DD MM YY)
06 04 11

2. REPORT TYPE
Technical Report

3. DATES COVERED (from – to)
Jun 2010 – Mar 2011

4. TITLE
Physical challenges associated with deployment-related injuries

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5a. Contract Number:
5b. Grant Number:
5c. Program Element Number:
5d. Project Number:
5e. Task Number:
5f. Work Unit Number: 60332

8. PERFORMING ORGANIZATION REPORT NUMBER
12-05

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10. SPONSOR/MONITOR'S ACRONYM(S)
NMRC/BUMED

11. SPONSOR/MONITOR'S REPORT NUMBER(s)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The health and physical fitness of US military forces are critical components of operational readiness. Service members who fail physical readiness and body composition standards may be at risk of discharge from the military. The aim of this study was to examine changes in physical readiness and body mass index (BMI) in US Navy service members with deployment-related injury. All aspects of postinjury Physical Readiness Test (PRT) performances declined from preinjury levels. Moderate to severe injury severity was a significant predictor of subsequent decline in overall PRT performance ($F = 19.9$, $df = 1$, $p < .001$). In addition, mean postinjury BMI ($M = 27.4$, $SD = 3.4$) was significantly higher than mean preinjury BMI ($F = 79.0$, $df = 1$, $p < .001$; $M = 26.1$, $SD = 2.9$). A decline in overall PRT performance was significantly associated with military discharge ($\chi^2 = 4.6$, $df = 1$, $p = .032$). Changes in BMI, however, were not associated with vocational outcomes. Overall, severity of deployment-related injury was associated with poor physical fitness after injury. Future research is needed to identify risk factors associated with these changes in injured combat veterans and should include a deployed, noninjured control group.

15. SUBJECT TERMS
military, injury severity, fitness, body mass index, vocational outcomes

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	18a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Commanding Officer
UNCL	UNCL	UNCL	UNCL	23	18b. TELEPHONE NUMBER (INCLUDING AREA CODE) COMM/DSN: (619) 553-8429

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18